US009069283B2

(12) **United States Patent**
Hatanaka

(10) **Patent No.: US 9,069,283 B2**
(45) **Date of Patent: Jun. 30, 2015**

(54) **IMAGE FORMATION UNIT AND IMAGE FORMATION APPARATUS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 45 days.

(21) Appl. No.: **13/862,522**

(22) Filed: **Apr. 15, 2013**

(65) **Prior Publication Data**

US 2013/0279925 A1 Oct. 24, 2013

(30) **Foreign Application Priority Data**

Apr. 18, 2012 (JP) 2012-094825

(51) **Int. Cl.**
G03G 15/08 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/0824*** (2013.01); ***G03G 15/0858*** (2013.01); ***G03G 15/0862*** (2013.01); ***G03G 15/0849*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/0856; G03G 15/0839; G03G 15/0824; G03G 15/0862; G03G 15/0849; G03G 15/0858
USPC 39/27, 255; 399/27, 255
See application file for complete search history.

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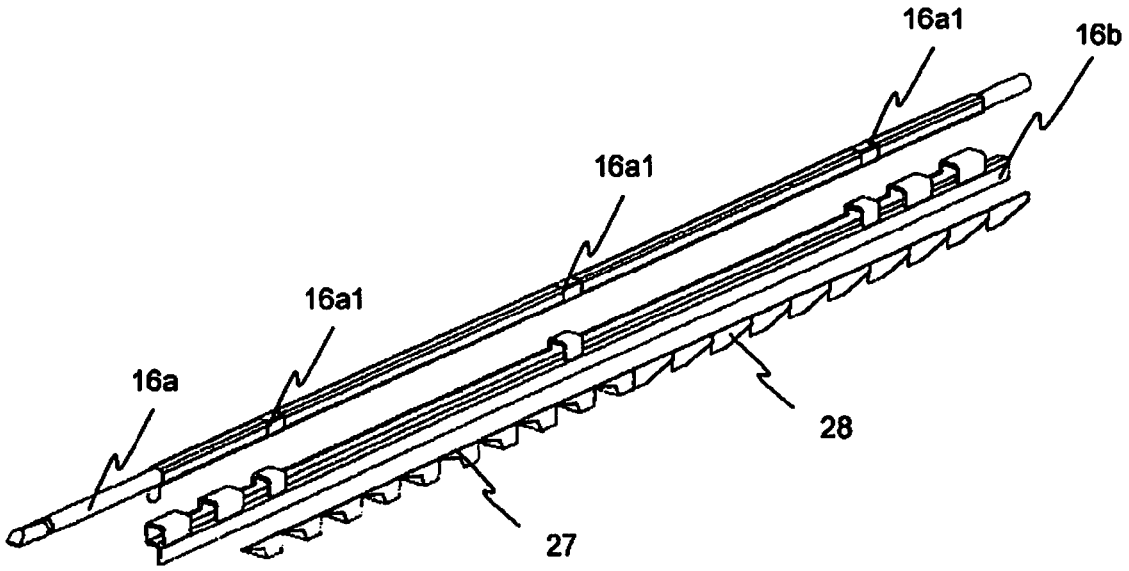
(57) **ABSTRACT**

An image formation unit includes a developer storage configured to store developer, an image carrier on which an electrostatic latent image is formed, a developer carrier being in contact with the image carrier and configured to transfer developer to the electrostatic latent image, a developer housing portion located below the developer storage and above the image carrier and configured to house the developer from the developer storage, a supply port provided above the developer housing portion to communicate with the developer storage and configured to supply the developer in the developer storage into the developer housing portion, a developer amount detection member rotatably disposed in the developer housing portion at a position below the supply port, and protrusions disposed on the developer amount detection member.

20 Claims, 17 Drawing Sheets



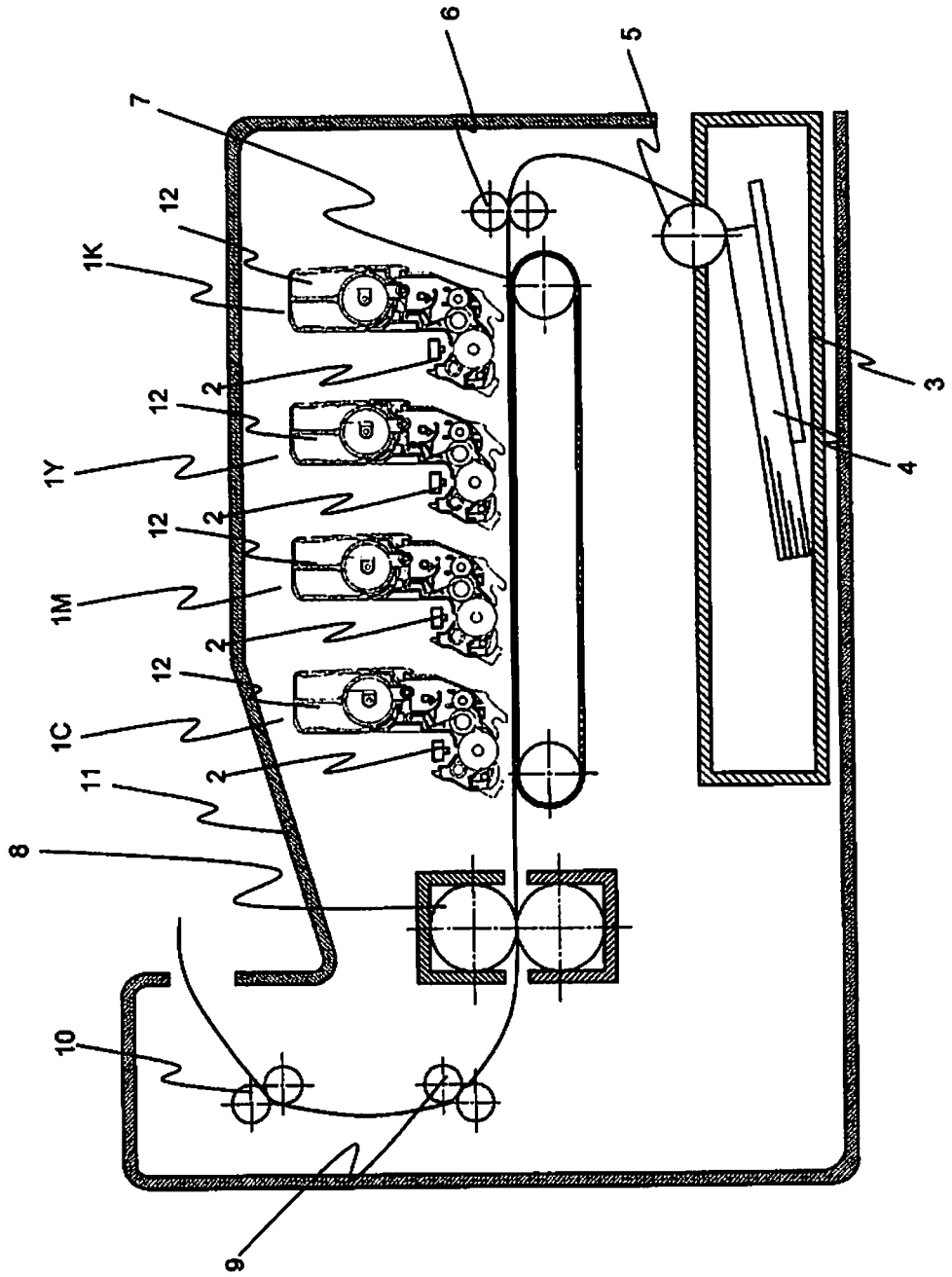
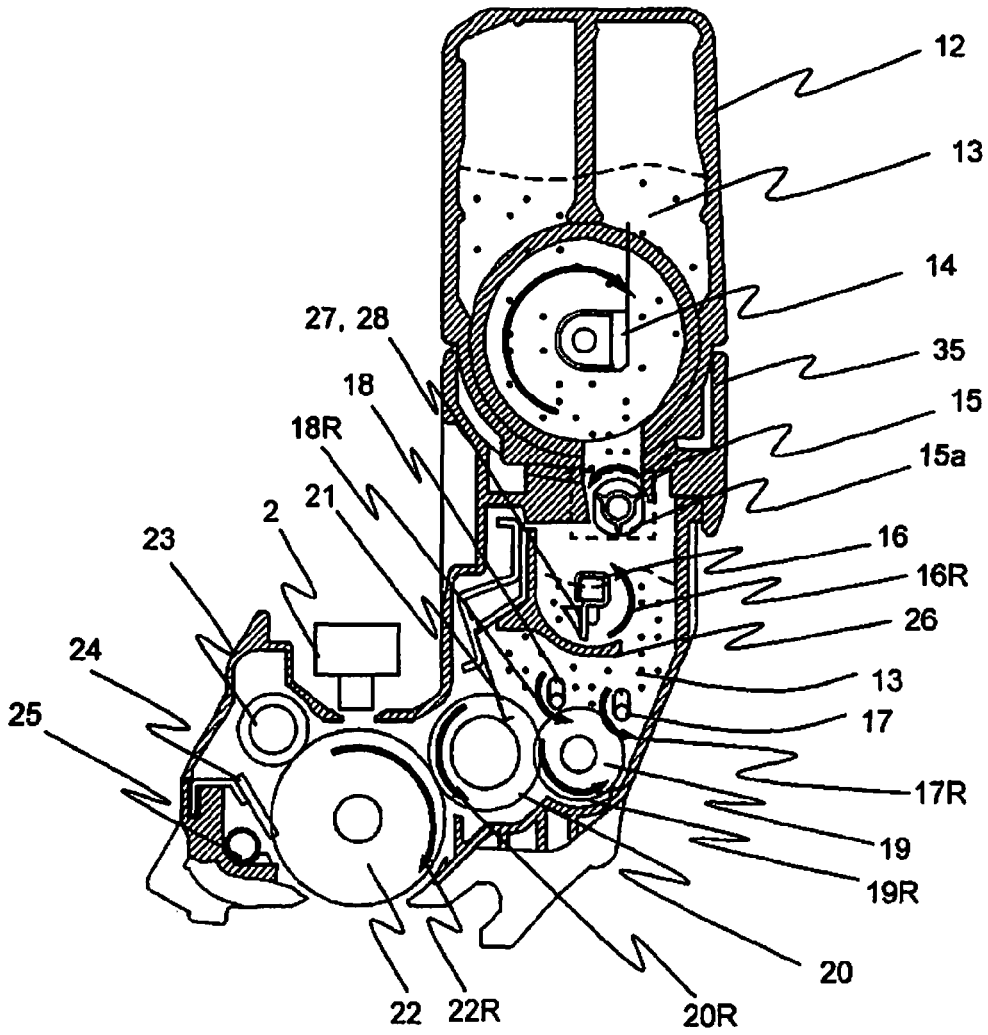


FIG. 1

FIG. 2


12
13
14
27, 28
35
18
15
18R
15a
21
2
16
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16R
26
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13
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17
17R
19
19R
20
22
22R
20R

FIG. 3

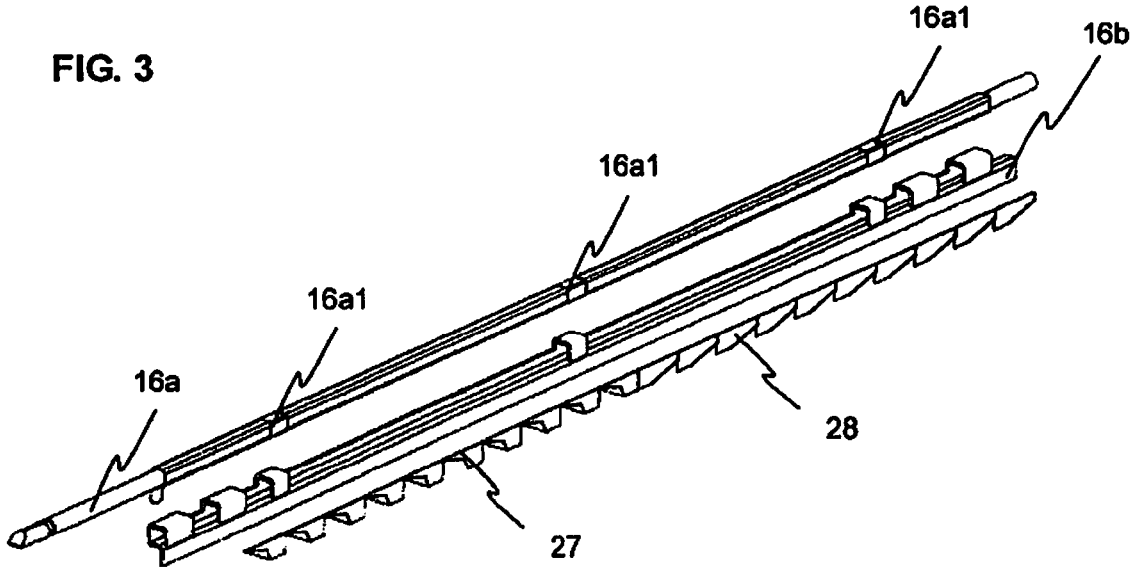
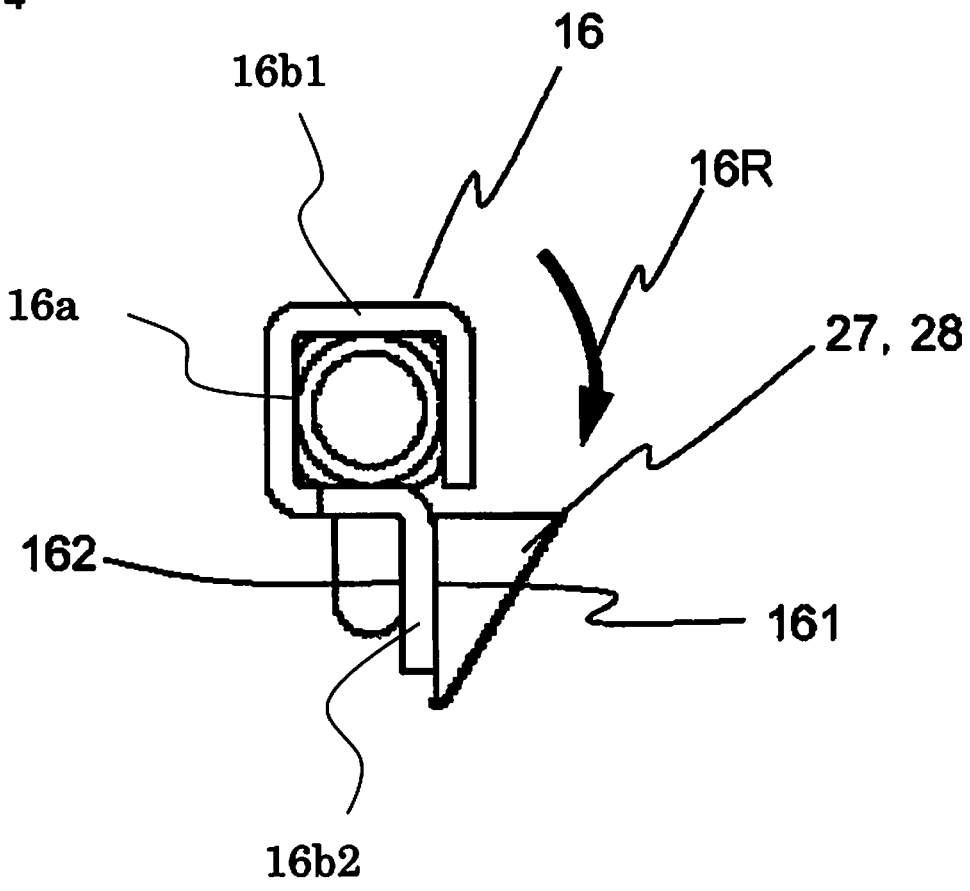


FIG. 4



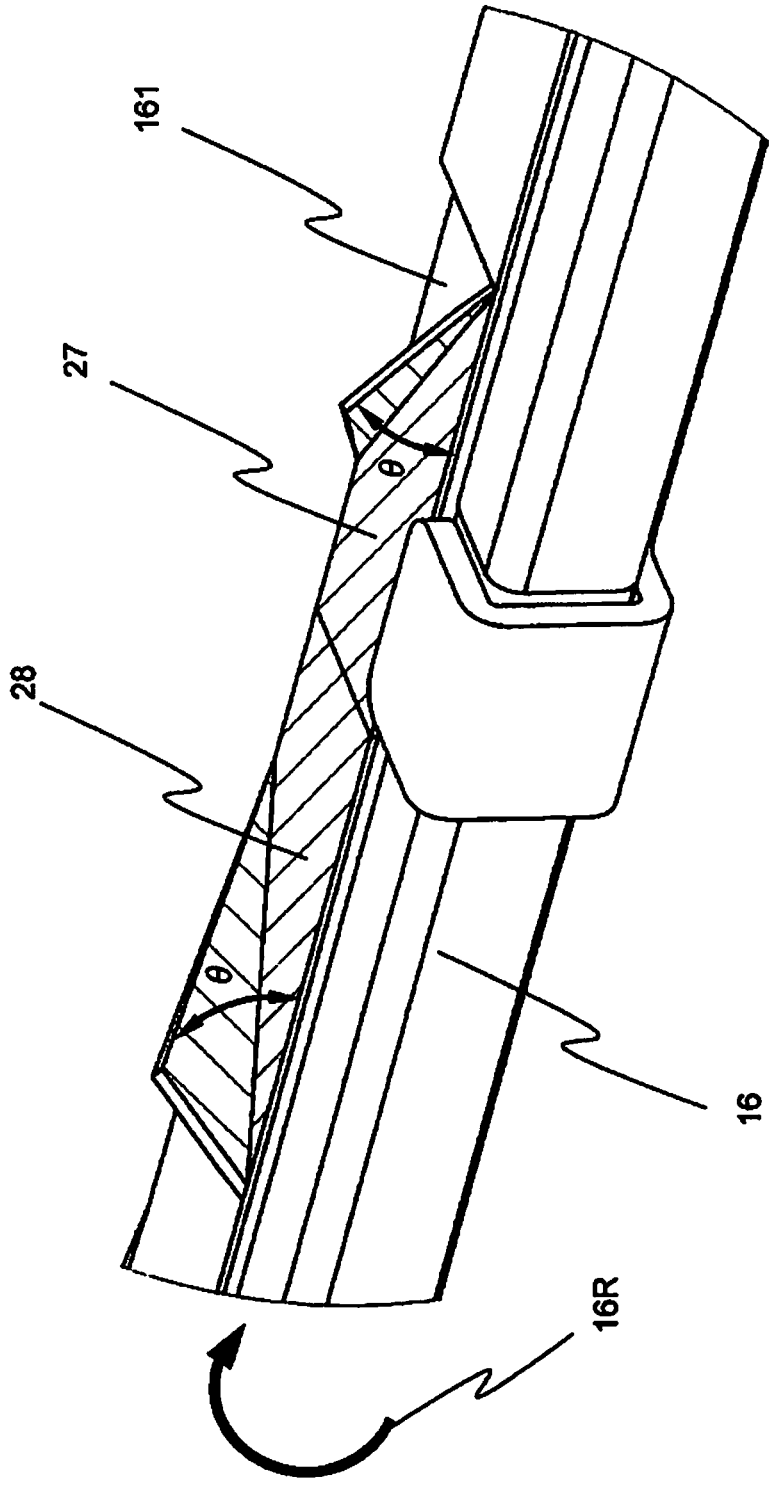


FIG. 5

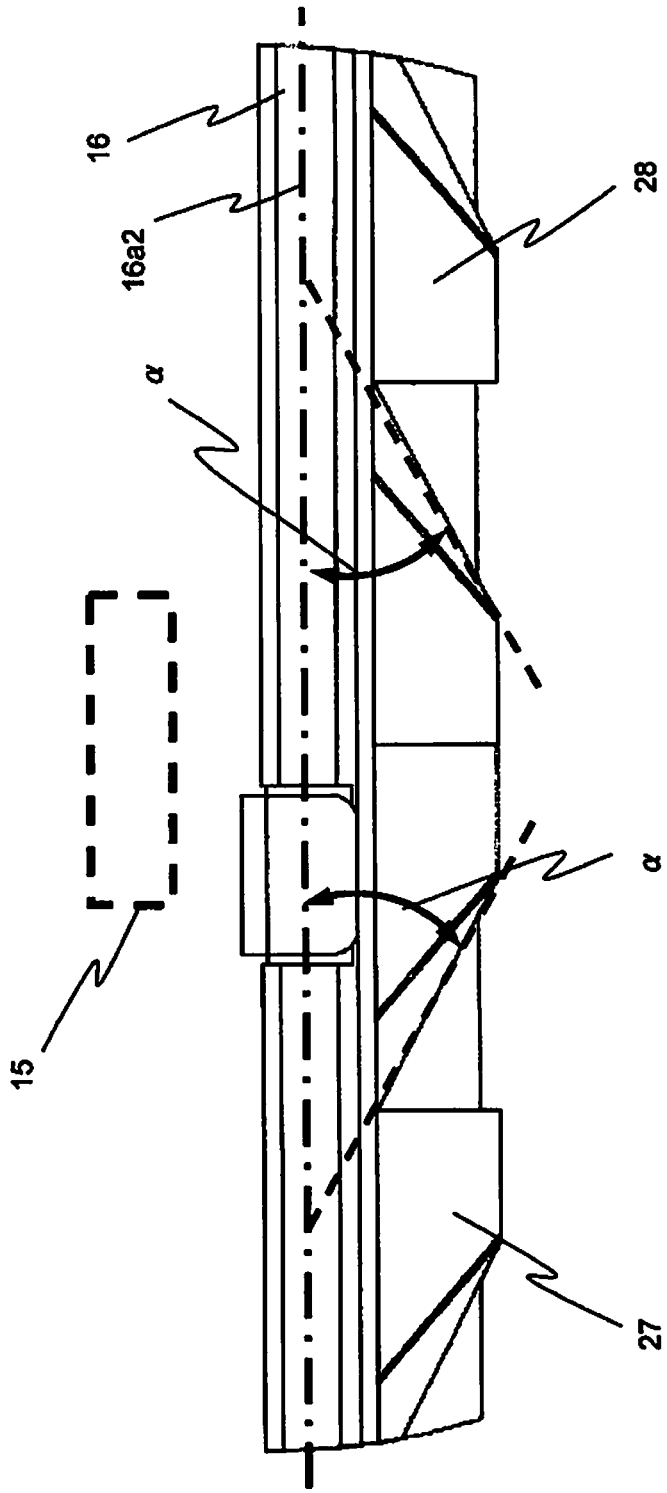


FIG. 6

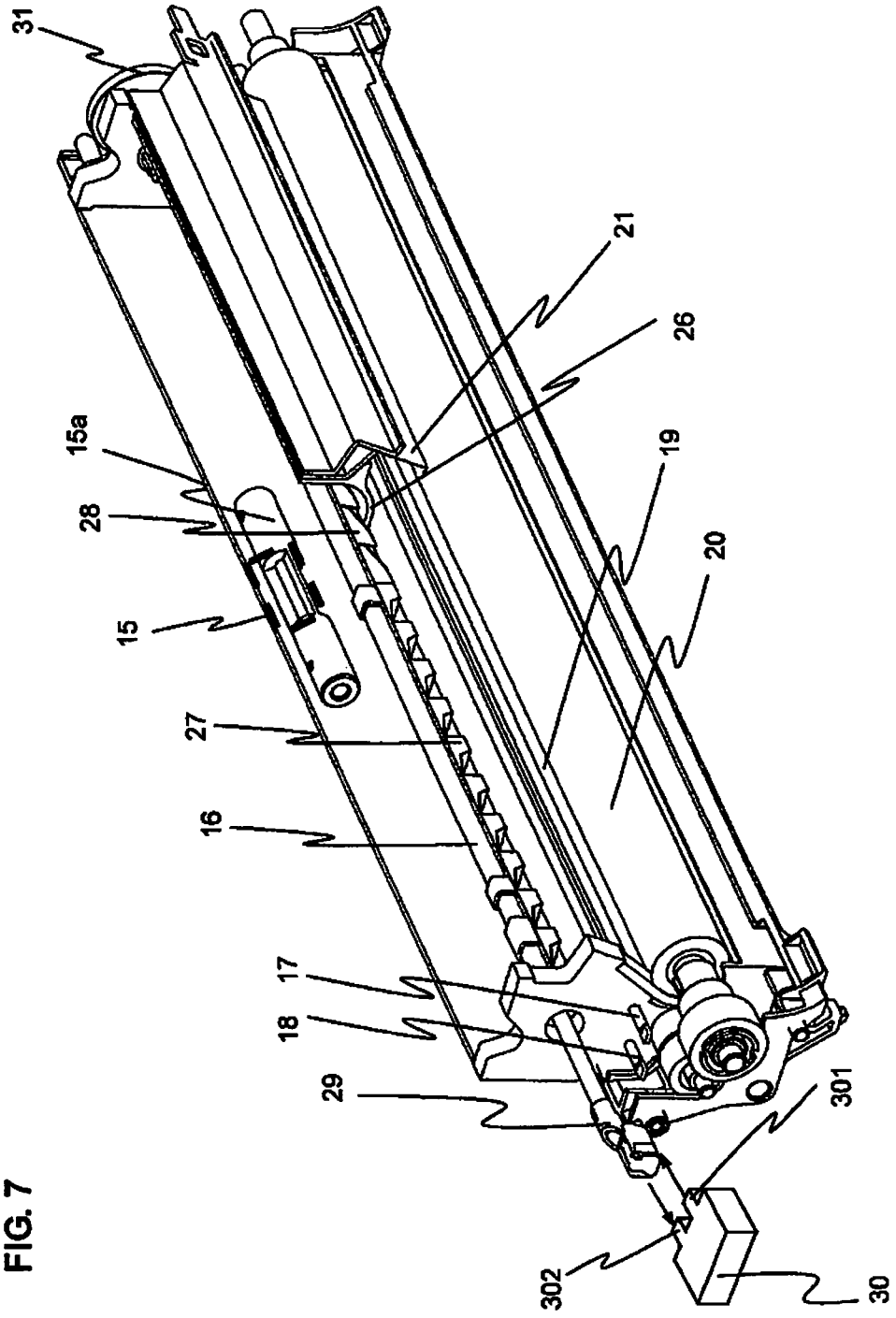


FIG. 7

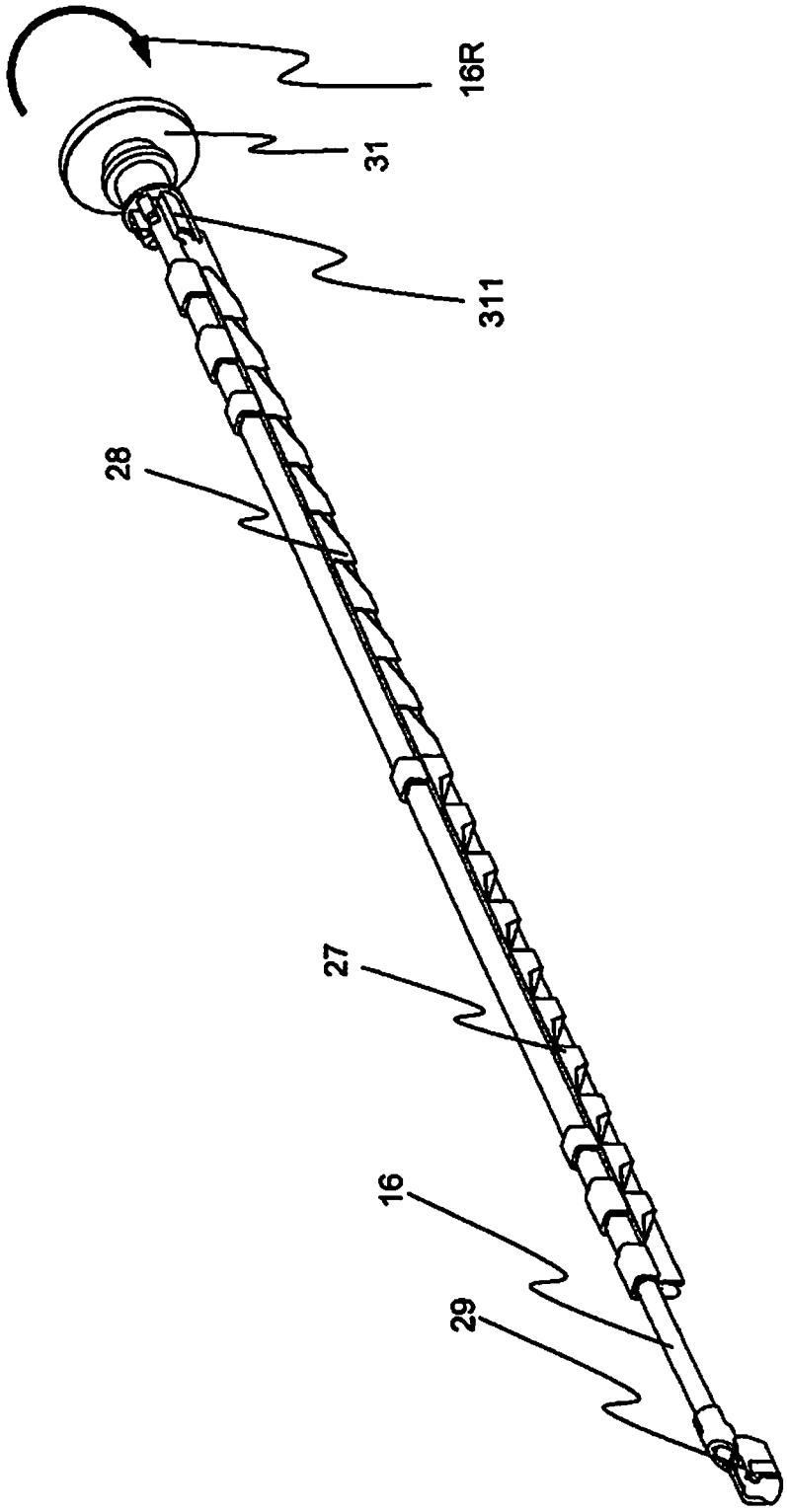


FIG. 8

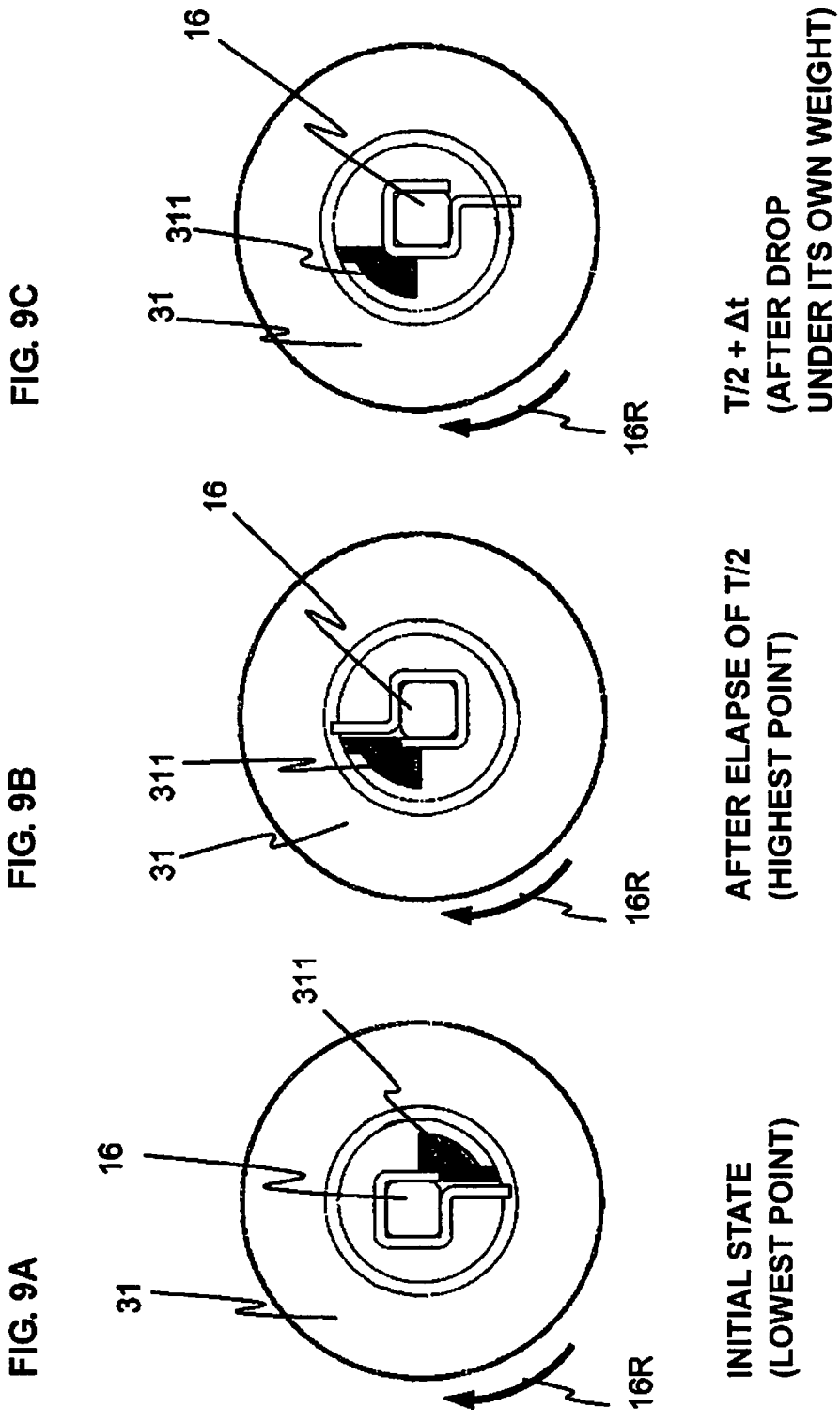


FIG. 9A
16
311
31
16R
INITIAL STATE
(LOWEST POINT)
FIG. 9B
16
311
31
16R
AFTER ELAPSE OF T/2
(HIGHEST POINT)
FIG. 9C
16
311
31
16R
T/2 + Δt
(AFTER DROP
UNDER ITS OWN WEIGHT)

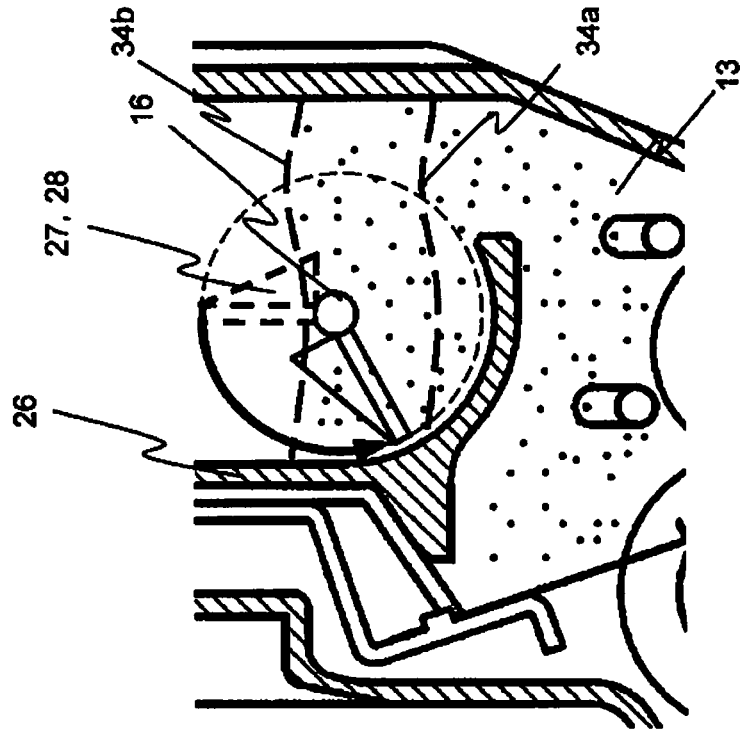


FIG. 10B

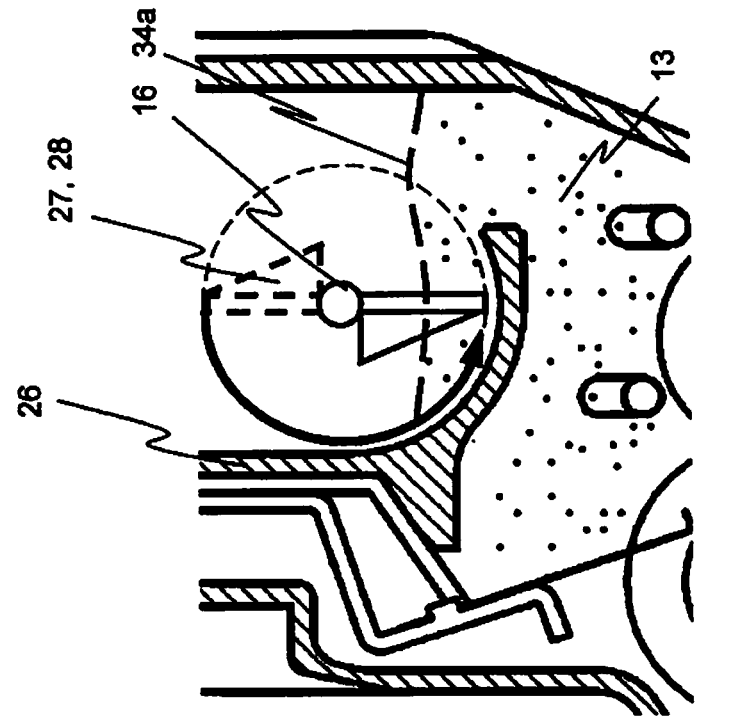


FIG. 10A

FIG. 11A

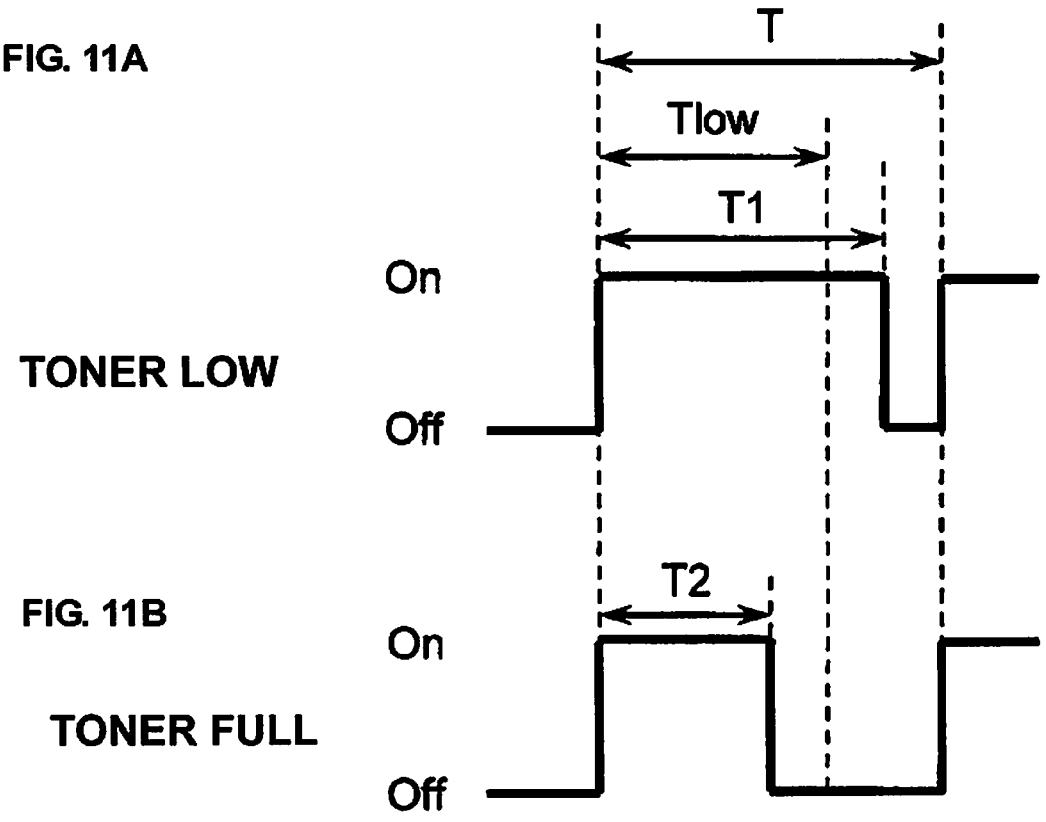


FIG. 11B

FIG. 12A

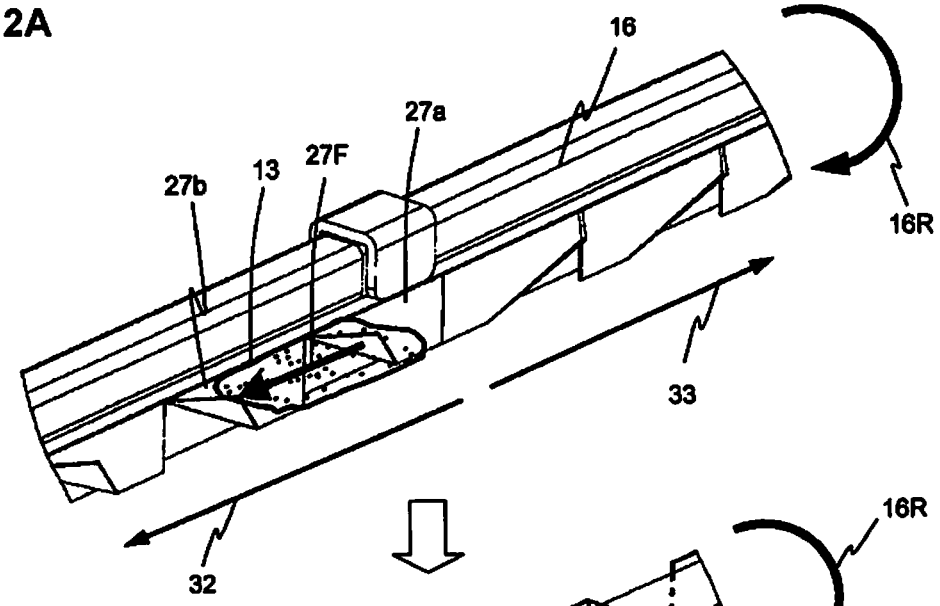


FIG. 12B

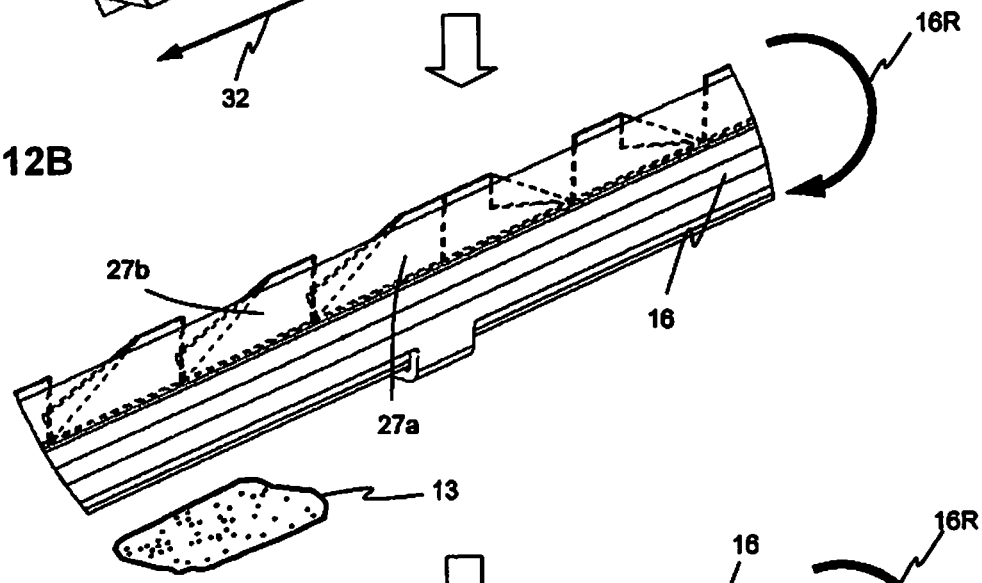
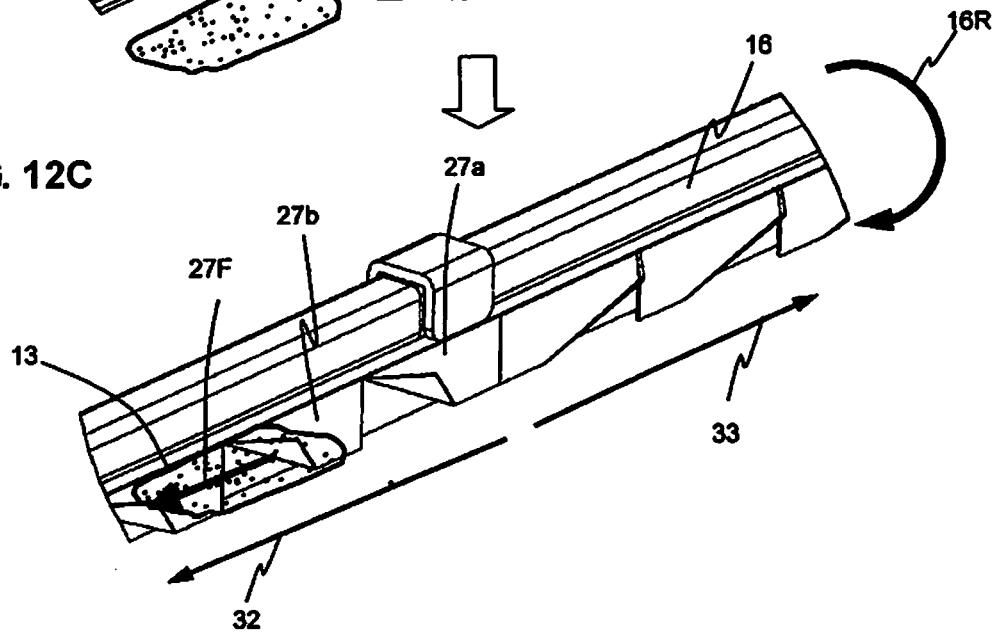
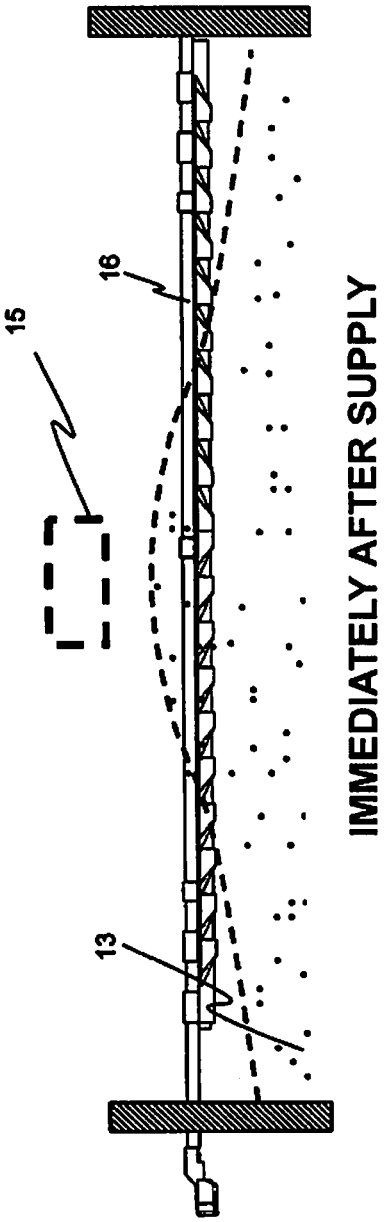


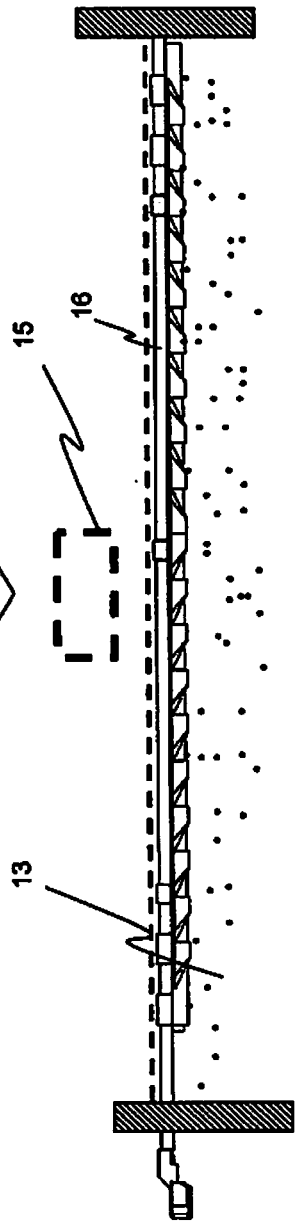
FIG. 12C





IMMEDIATELY AFTER SUPPLY

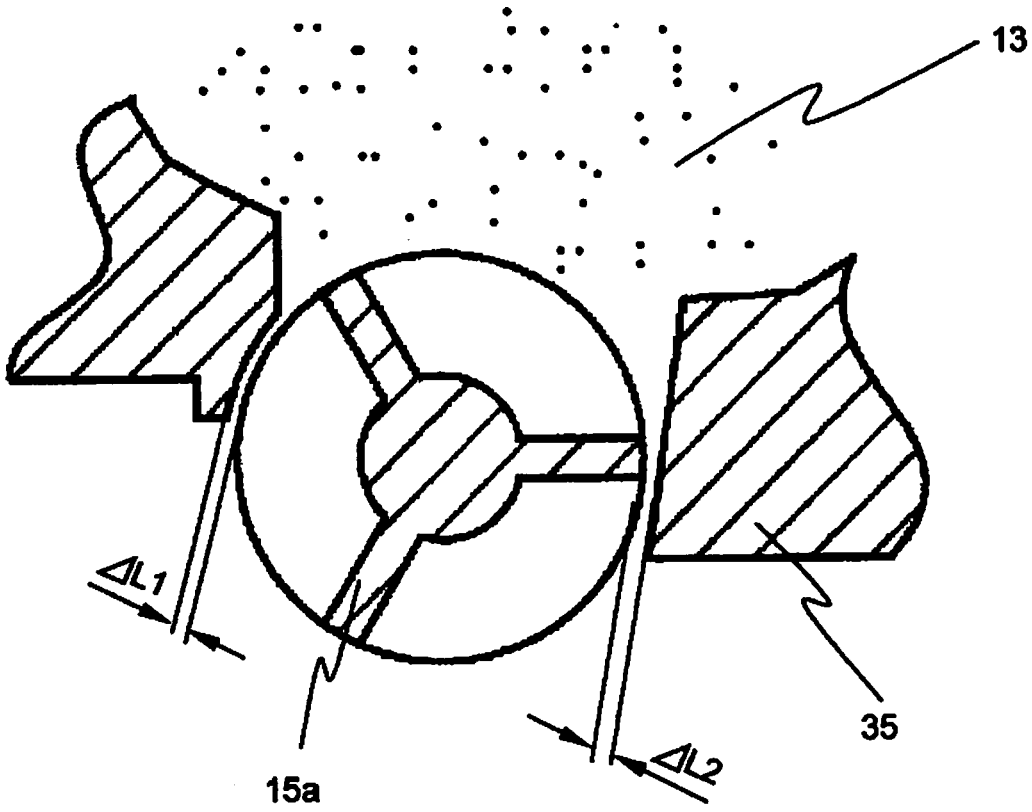
FIG. 13A



FTER ELAPSE OF Ta

FIG. 13B

FIG. 14



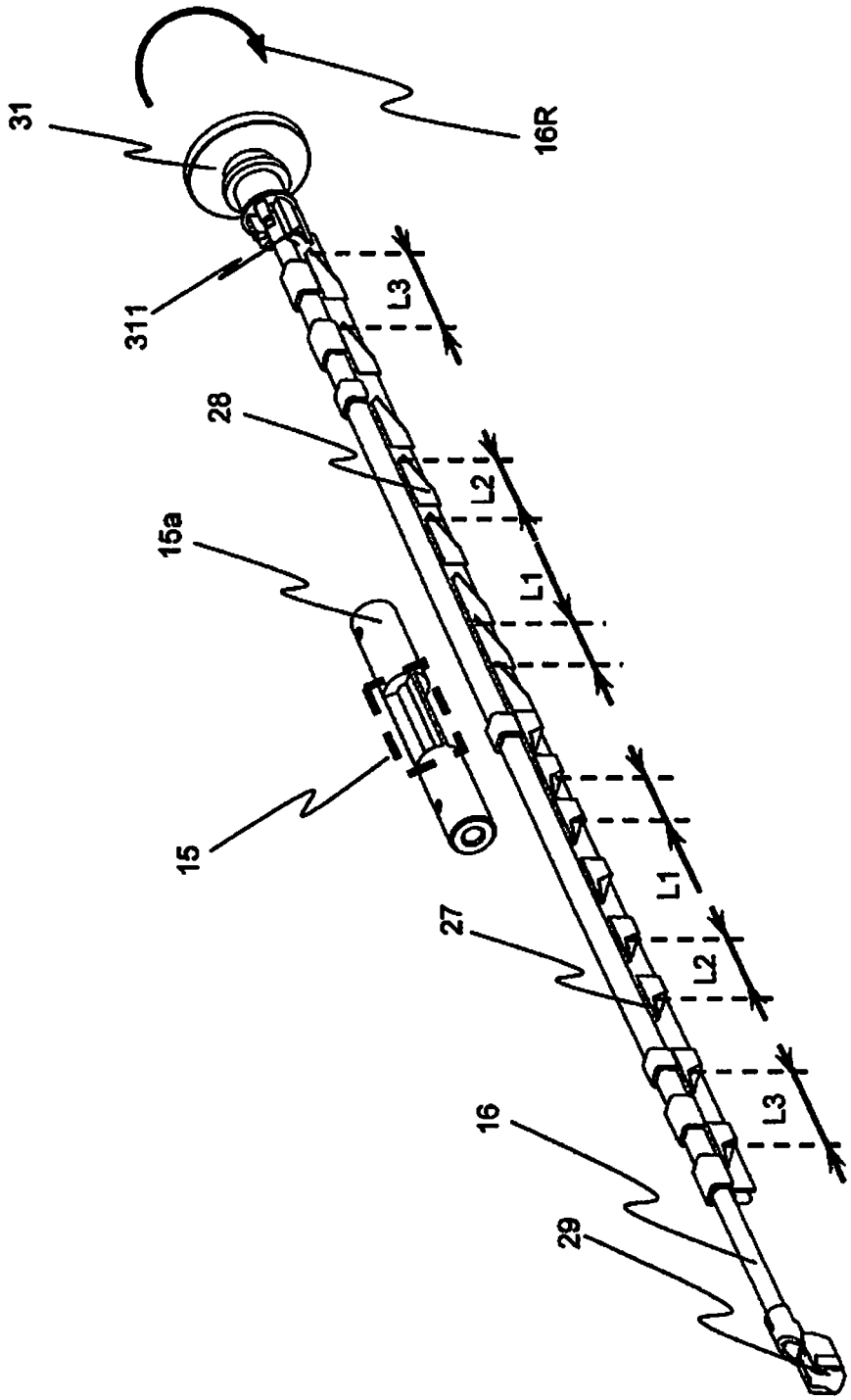
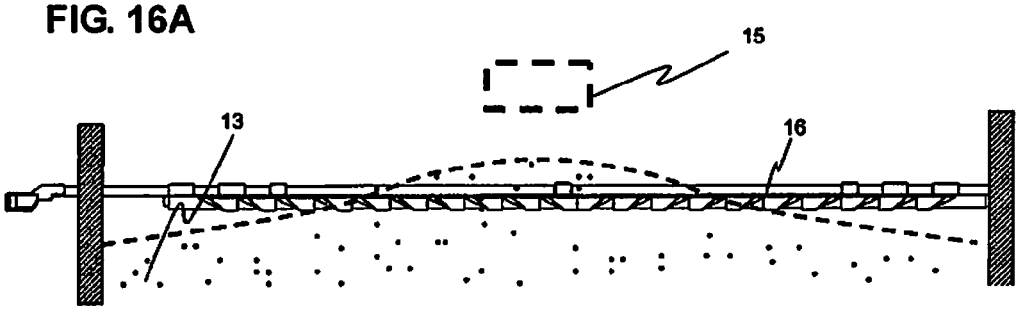


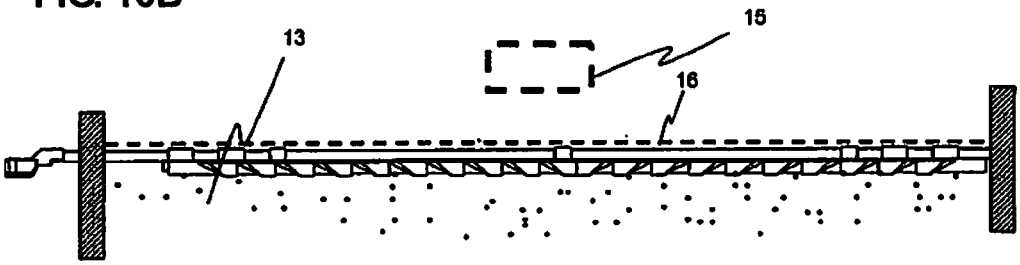
FIG. 15

FIG. 16A



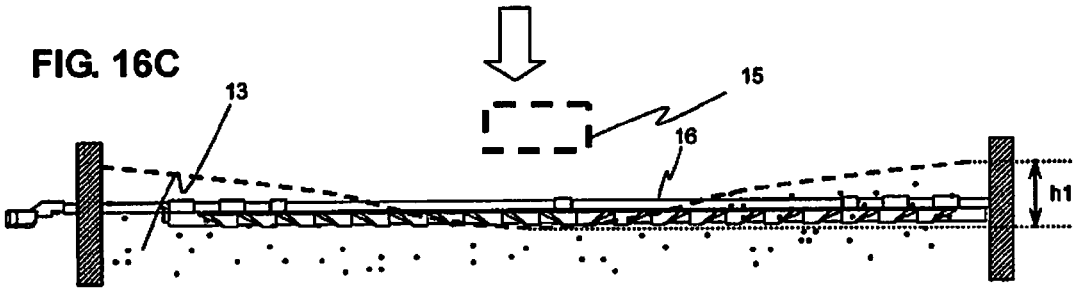
IMMEDIATELY AFTER SUPPLY

FIG. 16B



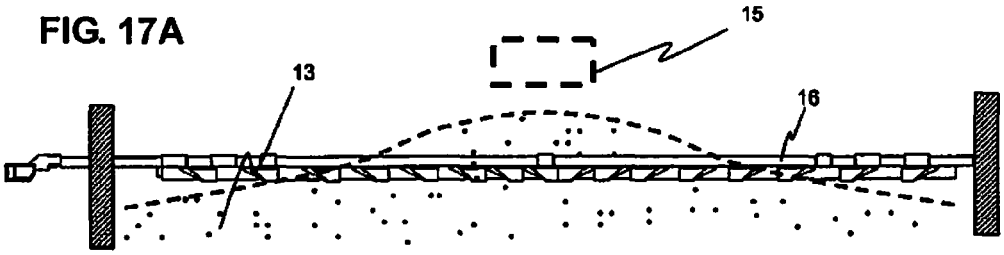
AFTER ELAPSE OF Ta

FIG. 16C



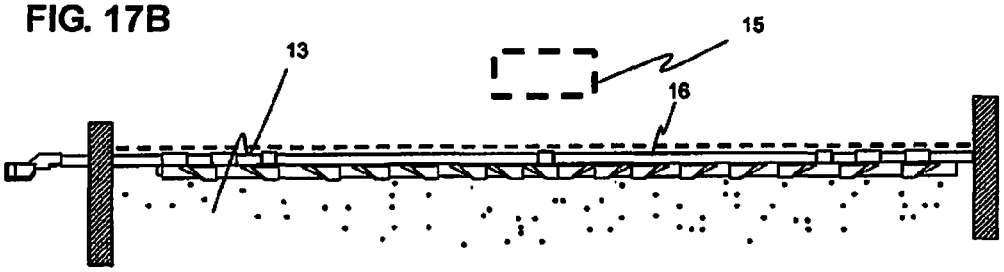
AFTER ELAPSE OF Tb

FIG. 17A



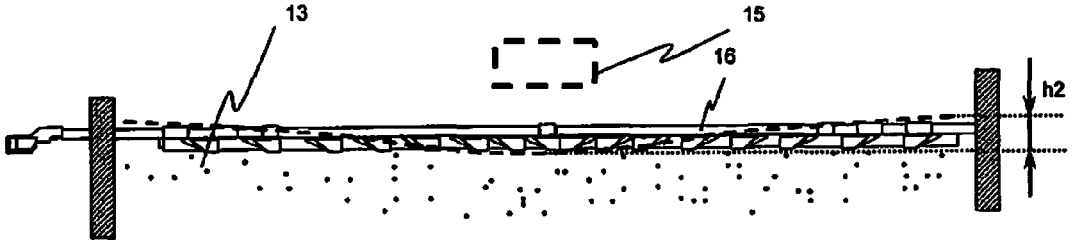
IMMEDIATELY AFTER SUPPLY

FIG. 17B



AFTER ELAPSE OF T'a

FIG. 17C



AFTER ELAPSE OF Tb

IMAGE FORMATION UNIT AND IMAGE FORMATION APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority based on 35 USC 119 from prior Japanese Patent Application No. 2012-094825 filed on Apr. 18, 2012, entitled "IMAGE FORMATION UNIT AND IMAGE FORMATION APPARATUS", the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The disclosure relates to an image formation unit and an image formation apparatus improved to solve problems of a deficiency in the amount of developer and an uneven distribution of the developer.

2. Description of Related Art

Image formation apparatuses having a function to solve problems of a deficiency of the amount of a developer, and an uneven distribution of the developer in an image formation unit, are generally known. Japanese Patent Application Publication No. 2005-221859 (Patent Document 1) is an example of such image formation apparatuses.

In the image formation apparatus of Patent Document 1, a stirring member is provided, in a longitudinal direction, in a portion of an image formation unit. The stirring member has functions to detect the amount of toner in the image formation unit and to stir the toner. The stirring member stirs the toner supplied through a toner supply port which is provided at the center, in the longitudinal direction, of the image formation unit. In other words, the stirring member detects the amount of toner as well as solves the problem of an uneven distribution of toner.

SUMMARY OF THE INVENTION

Even the conventional image formation apparatus of the above configuration cannot sufficiently solve the problem of uneven distribution of toner in some cases. In this case, image quality may be degraded.

A first aspect of the invention is an image formation unit that includes: a developer storage configured to store developer; an image carrier on which an electrostatic latent image is formed; a developer carrier being in contact with the image carrier and configured to transfer developer to the electrostatic latent image; a developer housing portion located below the developer storage and above the image carrier and configured to house the developer from the developer storage; a supply port provided above the developer housing portion to communicate with the developer storage and configured to supply the developer in the developer storage into the developer housing portion; a developer amount detection member rotatably disposed in the developer housing portion at a position below the supply port; and protrusions disposed on the developer amount detection member.

This aspect can bring the distribution of developer in the image formation unit close to being even, thus improving image quality.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional view showing a schematic configuration of an image formation apparatus according to a first embodiment of the invention.

FIG. **2** is a cross-sectional view showing an image formation unit according to the first embodiment.

FIG. **3** is an exploded perspective view showing a toner amount detection member according to the first embodiment.

FIG. **4** is a front view showing the toner amount detection member according to the first embodiment.

FIG. **5** is a perspective view showing a magnified version of a main part of the toner amount detection member according to the first embodiment.

FIG. **6** is a side view showing a magnified version of the main part of the toner amount detection member according to the first embodiment.

FIG. **7** is a perspective view showing the image formation unit according to the first embodiment.

FIG. **8** is a perspective view showing the toner amount detection member according to the first embodiment.

FIGS. **9**A, **9**B, and **9**C are schematic views showing operations of the toner amount detection member according to the first embodiment.

FIGS. **10**A and **10**B are cross-sectional views showing a magnified version of a main part of the image formation unit according to the first embodiment.

FIGS. **11**A and **11**B are time charts showing time periods in which the toner amount detection member according to the first embodiment stays at the lowest point.

FIGS. **12**A, **12**B, and **12**C are schematic views showing operations of protrusions of the toner amount detection member according to the first embodiment.

FIGS. **13**A and **13**B are schematic views showing a change of toner before and after being leveled by the protrusions of the toner amount detection member according to the first embodiment.

FIG. **14** is a cross-sectional view showing a toner supply port of the image formation unit according to the first embodiment.

FIG. **15** is a perspective view showing a toner amount detection member according to a second embodiment of the invention.

FIGS. **16**A, **16**B, and **16**C are schematic views showing changes in the accumulation state of toner before and after being leveled by the protrusions of the toner amount detection member of the first embodiment.

FIGS. **17**A, **17**B, and **17**C are schematic views showing changes in the accumulation state of toner before and after being leveled by protrusions of the toner amount detection member of the second embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

Descriptions are provided hereinbelow for embodiments based on the drawings. In the respective drawings referenced herein, the same constituents are designated by the same reference numerals and duplicate explanation concerning the same constituents is omitted. All of the drawings are provided to illustrate the respective examples only.

Hereinbelow, an image formation unit and an image formation apparatus according to embodiments of the invention are described. Note that, in this specification, an image formation apparatus incorporating an image formation unit is described.

First Embodiment

First of all, a first embodiment of the invention is described. FIG. **1** is a cross-sectional view showing a schematic configuration of an image formation apparatus according to this embodiment. The image formation apparatus shown in FIG. **1**

is an image formation apparatus capable of color printing, and has four image formation units. Specifically, the image formation apparatus has four image formation units **1**K, **1**Y, **1**M, **1**C for forming images of four colors, i.e., K (black), Y (yellow), M (magenta), and C (cyan). Exposure head **2** is disposed above later-described photosensitive drum **22** (see FIG. **2**) of each of image formation units **1**K, **1**Y, **1**M, **1**C with a certain gap in between.

Tray **3** is disposed below image formation units **1**K, **1**Y, **1**M, **1**C, and medium **4** is stored in tray **3**. Medium **4** is conveyed on a conveyance path formed by feed roller **5**, conveyance rollers **6**, and the like. Along the conveyance path for medium **4**, there are disposed: image formation units **1**K, **1**Y, **1**M, **1**C; transfer belt **7** on which to transfer, onto medium **4**, images formed by image formation units **1**K, **1**Y, **1**M, **1**C; fixing unit **8** configured to fix images transferred onto medium **4**; ejection rollers **9**, **10** configured to eject medium **4** outside the apparatus; and stacker cover **11** on which to keep ejected medium **4**.

In addition, toner storage container **12**, as a developer storage configured to store developer, is provided in an upper portion of each of image formation units **1**K, **1**Y, **1**M, **1**C. Toner storage containers **12** of image formation units **1**K, **1**Y, **1**M, **1**C store therein toners K, Y, M, and C of four colors, respectively.

Since image formation units **1**K, **1**Y, **1**M, **1**C have the same configuration and toner storage containers **12** have the same configuration, only one set of these is hereinafter described. Specifically, a set of image formation unit **1**K of color K (black) and toner storage container **12** of image formation unit **1**K is described.

FIG. **2** is a cross-sectional view showing image formation unit **1**K. Toner storage container **12** of image formation unit **1**K in FIG. **2** includes stirring member **14** configured to stir toner **13** as a developer. Toner storage container **12** is provided with toner supply port **15** as a developer supply port at a position below stirring member **14**. Toner supply port **15** is provided with rotatable shutter member **15***a* capable of opening and closing toner supply port **15**. Developer housing portion S is provided inside image formation unit **1**K. Developer housing portion S is a space located below toner storage container **12** and above photosensitive drum **22** as an image carrier. Developer housing portion S houses therein toner **13** supplied through toner supply port **15** of toner storage container **12**. Toner **14** in toner storage container **12** is supplied to developer housing portion S of image formation unit **1**K by opening toner supply port **15** by means of rotatable shutter member **15***a*. Toner supply port **15** is an opening for supplying toner **13** from toner storage container **12** to developer housing portion S. Toner supply port **15** is provided above a central portion, in a longitudinal direction, of developer housing portion S in such a way as to communicate with toner storage container **12**.

Image formation unit **1**K includes, in the inside: toner amount detection member **16** as a developer amount detection member; stirring members **17**, **18**; toner feed roller **19**; and development roller **20** as a developer carrier.

Each of stirring members **17**, **18** is a member for stirring toner **13**. Stirring members **17**, **18** are arranged inside developer housing portion S of image formation unit **1**K in parallel with the longitudinal direction of developer housing portion S. Each of stirring members **17**, **18** is rotatable. Toner **13** is stirred by rotation of stirring members **17**, **18**.

Toner feed roller **19** is a roller configured to feed toner **13** to development roller **20**. Development roller **20** is a roller configured to hold, on its surface, a thin layer of toner **13** to be transferred to an electrostatic latent image on photosensitive drum **22**. Development roller **20** transfers developer to the electrostatic latent image by contacting photosensitive drum **22**. Development blade **21** is disposed in contact with development roller **20**. Development blade **21** is a member configured to thin a layer of toner **13** on development roller **20**, fed from toner feed roller **19**. Photosensitive drum **22** is a roller on whose surface an electrostatic latent image can be formed. Charging roller **23** is a roller for charging the surface of photosensitive drum **22**. Cleaning blade **24** is a member configured to scrape off toner **13** attached on the surface of photosensitive drum **22**. Discarded toner conveyance member **25** is a device configured to discharge, to the outside, toner **13** scraped off of the surface of photosensitive drum **22** by cleaning blade **24**.

Photosensitive drum **22** is disposed in contact with development roller **20**. Charging roller **23** and cleaning blade **24** are disposed in contact with photosensitive drum **22**. Discarded toner conveyance member **25** is disposed facing cleaning blade **24**.

Next, toner amount detection member **16** is described.

Toner amount detection member **16** is a device configured to detect the amount of toner based on its rotation which varies in accordance with the amount of toner inside developer housing portion S. As shown in FIG. **2**, toner amount detection member **16** is disposed below toner supply port **15**. Toner amount detection member **16** is rotatably disposed, in a longitudinal direction, in a portion of image formation unit **1**K.

Toner amount detection member **16** is in the form of a paddle having a flat surface that protrudes from its rotational axis toward one side in a radial direction. Thereby, toner amount detection member **16** has a configuration where its center of gravity is eccentric from the rotational axis toward the paddle. To put it differently, toner amount detection member **16** is a member which generates a moment of inertia to rotate toner amount detection member **16** in such a way that the center of gravity of toner amount detection member **16** is moved to its lowest point. This moment of inertia is a moment to rotate toner amount detection member **16** in such a way that the center of gravity of toner amount detection member **16** is moved to its highest point as toner amount detection member **16** is rotated, and is moved to the lowest point under the weight of the center of gravity once passing the highest point.

As shown in FIG. **3**, toner amount detection member **16** mainly includes shaft portion **16***a* and plate-shaped portion **16***b*.

Shaft portion **16***a* is a member serving as the rotational axis of toner amount detection member **16**. Shaft portion **16***a* is rotatably provided in developer housing portion S of image formation unit **1**K. Later-described drive gear **31** (see FIG. **8**) is provided in one end portion, in a longitudinal direction, of shaft portion **16***a*. Reflector plate **29** (see FIG. **8**) of later-described sensor **30** is provided in the other end portion, in the longitudinal direction, of shaft portion **16***a*.

Plate-shaped portion **16***b* is a member being in direct contact with toner **13** and is configured to change a rotation stop position in accordance with the amount of toner. Plate-shaped portion **16***b* includes crimping portion **16***b***1** and paddle portion **16***b***2**. Crimping portion **16***b***1** is a member for joining shaft portion **16***a* and plate-shaped portion **16***b* integrally. Shaft portion **16***a* and plate-shaped portion **16***b* are joined together by crimping crimping portion **16***b***1** into grooves **16***a***1** of shaft portion **16***a*. Paddle portion **16***b***2** is a member for stirring toner **13**, making the center of gravity eccentric, and supporting protrusions **27**, **28**. Paddle portion **16***b***2** is formed of a plate-shaped member having a flat surface. More specifically, paddle portion **16***b***2** is formed of a flat plate

extending in a rotational axis direction of toner amount detection member **16** and protruding in the radial direction thereof. Toner **13** is stirred by making plate-shaped paddle portion **16***b***2** rotate about shaft portion **16***a*.

Paddle portion **16***b***2** is a member for making eccentric the center of gravity of toner amount detection member **16**. Toner amount detection member **16** is configured in such a way that paddle portion **16***b***2**, where the center of gravity is located, is rotated about shaft portion **16***a* by a drive source and, once passing the highest point, paddle portion **16***b***2** rotates irrespective of the drive source to move to the lowest point by the action of the moment of inertia (under the weight of paddle portion **16***b***2** (the weight of the center of gravity)). In addition, by the rotation under its own weight, paddle portion **16***b***2** contacts toner **13** as well as changes the rotation stop position in accordance with the amount of toner. More specifically, paddle portion **16***b***2** stops its rotation at a position close to the lowest point when the amount of toner is small, and at a position far from the lowest point when the amount of toner is large.

Protrusions **27**, **28** function to spread toner **13**, in a longitudinal direction, in a central portion of toner amount detection member **16**, toward two sides thereof in the longitudinal direction. Protrusions **27**, **28** are each a member configured to scoop the toner with the rotation of toner amount detection member **16**, and they work in conjunction with one another to spread toner **13**, which is supplied through toner supply port **15**, toward the two ends, in the longitudinal direction, of toner amount detection member **16**. Multiple protrusions **27**, **28** are arranged in paddle portion **16***b***2** of toner amount detection member **16** in parallel with one another at equal intervals. Protrusions **27**, **28** together act like a screw to convey and spread toner **13**, which is supplied to the vicinity of the center, in the longitudinal direction, of image formation unit **1**K (developer housing portion S), toward the two ends thereof in the longitudinal direction. To this end, protrusions **27** are arranged on one side of image formation unit **1**K and protrusions **28** are arranged on the other side thereof with respect to the center, in the longitudinal direction, of image formation unit **1**K. Thereby, protrusions **27**, **28** are capable of spreading toner **13** in the center, in the longitudinal direction, of image formation unit **1**K toward the two sides thereof. As shown in FIG. **4**, protrusions **27**, **28** are formed from a bent film member. Protrusions **27**, **28** are bonded to flat surface **161** of plate-shaped portion **16***b*, which is a trailing surface relative to the direction of rotation of toner amount detection member **16**.

In addition, as shown in FIG. **5**, each of protrusions **27**, **28** has a bent edge portion, and thereby protrudes from flat surface **161**. This protrusion angle is set at $\theta=60°$. Each of protrusions **27**, **28** is inclined at angle α in such a manner as to extend in a radial direction of rotational axis **16***a***2** from rotational axis **16***a***2** and in a direction from an end portion, in the radial direction, of flat surface **161** toward supply port **15**. This angle α is set at $0°<\alpha<90°$. In this way, the film member bent at angles θ and α acts like blades of a screw. Thereby, protrusions **27**, **28** each push toner **13** in the central portion, in the longitudinal direction, of toner amount detection member **16** toward the two sides thereof in the longitudinal direction, and they work in conjunction with one another to spread toner **13** in the central portion, in the longitudinal direction, of toner amount detection member **16** toward the two sides thereof in the longitudinal direction. Further, protrusions **27**, **28** are bonded to flat surface **161** of plate-shaped portion **16***b*, which is the trailing surface relative to the direction of rotation of toner amount detection member **16**, and thus do not disturb the toner amount detection function of toner amount detection member **16**.

As shown in FIGS. **2**, **7**, **10**A and **10**B, enclosure member **26** covering toner amount detection member **16** is disposed around toner amount detection member **16**. Enclosure member **26** is spaced a certain distance away from the rotation outer diameter of toner amount detection member **16**. Enclosure member **26** has a shape covering an arc of (i.e. the lower **90** or more degrees of, see FIGS. **10**A and **10**B) the rotation trajectory drawn by toner amount detection member **16** when the member rotates from the highest point to the lowest point. Moreover, enclosure member **26** is formed covering the lowest point from below. Thereby, enclosure member **26** temporarily holds toner **13** supplied through toner supply port **15**. Besides, the interval between the inner surface of enclosure member **26** and rotating toner amount detection member **16** is set small. Thereby, in combination with protrusions **27**, **28**, enclosure member **26** acts like a trough of a screw conveyor. Further, enclosure member **26** is formed covering the lowest point from below, thereby preventing the influence of the stir by stirring members **17**, **18**.

As shown in FIG. **8**, drive gear **31** as a drive unit is disposed in one end portion, in the longitudinal direction, of toner amount detection member **16**. Drive gear **31** is driven by a drive motor (not illustrated) as the drive source. Drive gear **31** has locking protrusion **311** configured to transmit the rotation of drive gear **31** to toner amount detection member **16**. In this way, toner amount detection member **16** is rotated by the rotation of drive gear **31**. Specifically, locking protrusion **311** contacts one surface (a right lateral surface in FIG. **8**) of paddle portion **16***b***2** of toner amount detection member **16** to rotate toner amount detection member **16**. More specifically, as shown in FIG. **9**A, locking protrusion **311** contacts the one surface of paddle portion **16***b***2** of toner amount detection member **16** located at the lowest point. Then, once toner amount detection member **16** is rotated to the highest point as shown in FIG. **9**B, paddle portion **16***b***2** of toner amount detection member **16** moves away from locking protrusion **311** and rotates to the lowest point under its own weight.

As shown in FIGS. **7** and **8**, reflector plate **29** is disposed in the other end portion, in the longitudinal direction, of toner amount detection member **16**. Reflector plate **29** is used for sensor **30**. Sensor **30** is configured to emit test light to reflector plate **29** and receive reflected light. Sensor **30** is disposed at a position opposed to reflector plate **29**, which rotates together with toner amount detection member **16**, at the time when reflector plate **29** is located at the lowest point on the rotation trajectory of reflector plate **29**. Sensor **30** includes light emission portion **301** and light reception portion **302**. Sensor **30** detects that the amount of remaining toner is reduced when light reception portion **302** receives test light emitted from light emission portion **301** and reflected by reflector plate **29** located at the lowest point. More specifically, when toner **13** is so reduced that paddle portion **16***b***2** of toner amount detection member **16** rotates to the lowest point without being blocked by toner **13**, light reception portion **302** detects reflected light, and thereby sensor **30** detects that the amount of remaining toner is reduced.

As shown in FIG. **1**, controller C configured to control the entire operation is provided inside the image formation apparatus. Controller C is connected to image formation units **1**K, **1**Y, **1**M, **1**C, feed roller **5**, and the like and controls these components.

The image formation apparatus having the above configuration operates as follows.

In FIG. **1**, upon receipt of a print instruction from controller C, medium **4** is separated from the others one by one by feed roller **5**. Separated medium **4** is conveyed to transfer belt **7** by conveyance rollers **6**. Meanwhile, development according to a later-described development process is carried out in each of image formation units **1**K, **1**Y, **1**M, **1**C, and toner **13** is transferred onto medium **4** conveyed on transfer belt **7**. Medium **4** on which toner **13** is transferred passes through fixing unit **8** where toner **13** is fixed thereon. Medium **4** is then ejected to stacker cover **11** by ejection rollers **9**, **10** and held on stacker cover **11**.

The development process in each of image formation units **1**K, **1**Y, **1**M, **1**C is described based on FIG. **2**. Note that, since image formation units **1**K, **1**Y, **1**M, **1**C have the same configuration, only image formation unit **1**K of color K (black) is described. Upon receipt of a print instruction from controller C, feed roller **19** is rotated by a drive source (not illustrated) in a direction indicated by arrow **19**R. Thereby, toner **13** is fed to development roller **20** rotated in a direction indicated by arrow **20**R. At this time, stirring members **17**, **18** are also rotated in directions indicated by arrows **17**R, **18**R respectively to stir toner **13**. A layer of toner **13** fed to development roller **20** is thinned by development blade **21** and charged.

In the meantime, the surface of photosensitive drum **22** rotated in a direction indicated by arrow **22**R is charged by charging roller **23**. Photosensitive drum **22** is then exposed by exposure head **2**, whereby an electrostatic latent image is formed on photosensitive drum **22**. Toner **13** on development roller **20** moves to this electrostatic latent image, and thereby the exposed part is developed. After that, the image is transferred to medium **4**. Toner **13** left on photosensitive drum **22** is scraped off by cleaning blade **24**. Toner **13** thus scraped off is conveyed and discharged to the outside by discarded toner conveyance member **25**.

Next, operations of toner amount detection member **16** and of the toner supply are described.

As shown in FIG. **9**A, paddle portion **16***b***2** of toner amount detection member **16** located at the lowest point is rotated in a manner pushed upward from the lowest point to the highest point by the action of locking protrusion **311** of drive gear **31**. Here, locking protrusion **311** of drive gear **31** is rotated in the direction indicated by arrow **16**R, which is the same as that of toner amount detection member **16**, at rotation period T. Hence, as shown in FIG. **9**B, paddle portion **16***b***2** reaches the highest point after the elapse of T/2. Then, once passing the highest point, paddle portion **16***b***2** rotates and drops to the lowest point under its own weight because the center of gravity is eccentric, as shown in FIG. **9**C.

In the state where the amount of toner **13** in image formation unit **1**K is small (such a state is termed as "toner low") and the level of toner upper surface **34***a* is low as shown in FIG. **10**A, toner amount detection member **16** hardly receives pressure from toner **13**. For this reason, paddle portion **16***b***2** of toner amount detection member **16** drops to the lowest point under its own weight and reaches the lowest point earlier than locking protrusion **311**. Accordingly, paddle portion **16***b***2** of toner amount detection member **16** is located at the lowest point as also is reflector plate **29**. Because sensor **30** is disposed opposed to the lowest point on the rotation trajectory of reflector plate **29**, the test light emitted from light emission portion **301** of sensor **30** is reflected by reflector plate **29**. Light reception portion **302** receives the reflected light, and sensor **30** thereby detects the position of toner amount detection member **16**. Controller C acquires a time period in which toner amount detection member **16** stays at the lowest point. Then, controller C judges that image formation unit **1**K is in the state of "toner low" if stay period T1 is longer than set period Tlow set in advance, as shown in FIG. **11**A.

If judging that image formation unit **1**K is in the state of "toner low", controller C issues a toner supply instruction. Upon issue of this instruction, rotatable shutter member **15***a* is rotated by a drive unit (not illustrated). By this rotation, toner **13** drops from toner storage container **12** and is supplied to image formation unit **1**K. In this event, since toner supply port **15** is provided in the vicinity of the center, in the longitudinal direction, of image formation unit **1**K, toner **13** is supplied to the vicinity of the center, in the longitudinal direction, of image formation unit **1**K. Then, since multiple protrusions **27** (**27***a*, **27***b* . . .) are rotated as shown in FIGS. **12**A, **12**B, and **12**C, protrusions **27** act like blades of a screw conveyor and produce force **27**F to push toner **13** in the axial directions of toner amount detection member **16**. Thus, toner **13** supplied through toner supply port **15** is first pushed by protrusion **27***a* in the vicinity of the center, in the longitudinal direction, of image formation unit **1**K and conveyed toward one side, in the longitudinal direction, of toner amount detection member **16** (in a direction indicated by arrow **32** in this example), and reaches protrusion **27***b* next to protrusion **27***a*. Likewise, protrusion **27***b* conveys toner **13** in the direction indicated by arrow **32**. By repeating this operation, supplied toner **13** is conveyed in the directions away from supply port **15** and never accumulates near an area below supply port **15**.

In this operation, enclosure member **26** covers a lower part of the rotation trajectory of protrusions **27**, **28**, and temporarily holds toner **13**. In this manner, enclosure member **26** suppresses the influence of stirring members **17**, **18** located near toner amount detection member **16** and thus enables protrusions **27**, **28** of toner amount detection member **16** to convey toner **13** smoothly.

In the same way, multiple protrusions **28** rotate and produce a force in an opposite direction from push force **27**F of multiple protrusions **27**, and thereby convey toner **13** toward the other side, in the longitudinal direction, of toner amount detection member **16** (in a direction indicated by arrow **33** in this example).

In addition, as shown in FIGS. **4** and **10**, since protrusions **27**, **28** are disposed on trailing surface **161** relative to the direction of rotation of toner amount detection member **16**, smooth surface **162** having no protrusions **27**, **28** always contacts toner upper surfaces **34***a*, **34***b* when the paddle portion drops under its own weight. For this reason, protrusions **27**, **28** never affect the toner amount detection.

As the amount of supplied toner **13** accumulating on enclosure member **26** becomes larger, toner amount detection member **16** receives more pressure from toner **13**. Accordingly, toner amount detection member **16** rotates in conjunction with locking protrusion **311** of drive gear **31** without dropping under its own weight.

Hence, stay period T2 in which toner amount detection member **16** stays at the lowest point becomes shorter as the amount of accumulating toner increases (i.e., stay period T2 becomes shorter as the time passes since the start of the toner supply). If stay period T2 becomes shorter than set period Tlow as shown in FIG. **11**B, controller C detects a state of "toner full" (i.e. an increase in the level of toner upper surface **34***b* shown in FIG. **10**B). After detecting the state of "toner full", controller C issues an instruction to stop rotatable shutter member **15***a* to stop the toner supply operation.

As shown in FIG. **13**A, toner **13** is piled up near supply port **15** and exhibits an uneven distribution immediately after the stopping of the toner supply. However, because toner **13** is

stirred and conveyed by protrusions **27**, **28**, toner **13** exhibits an even distribution after the elapse of period Ta to a level toner, as shown in FIG. **13**B.

As shown in FIG. **14**, minute gaps ΔL1, ΔL2 are established between rotatable shutter member **15***a* and cover **35**, making rotatable shutter member **15***a* rotatable. In addition, because gaps ΔL1, ΔL2 are minute, toner **13** having entered the gaps accumulates in the gaps. Hence, toner **13** in toner storage container **12** is held without dropping through the gaps.

As described above, protrusions **27**, **28** are provided to toner amount detection member **16** in this embodiment. Hence, toner **13** can be stirred and conveyed by the protrusions **27**, **28** even in the case where the fluidity of toner **13** is reduced due to deterioration of toner **13** or the like. Thus, toner **13** can be distributed evenly. This makes it possible to prevent toner **13** from accumulating near toner supply port **15**, and thereby to keep a good toner amount detection accuracy while preventing a deterioration thereof.

In addition, the problems of a deficiency of the amount of toner and an uneven distribution of toner are solved. Thereby, it is possible to keep a good image quality while preventing a deterioration thereof.

Further, the stir/conveyance of toner **13** and the toner amount detection can be carried out by the single component (toner amount detection member **16**), making it possible to reduce the number of components and cost.

On the other hand, in the case of the conventional image formation apparatus having no protrusions **27**, **28**, it is sometimes impossible to sufficiently solve the problem of an uneven distribution of toner caused when the fluidity of toner is reduced due to a deterioration of the toner or the like. To put it differently, when the fluidity of toner is reduced in the conventional image formation apparatus due to a deterioration of the toner or the like, toner is likely to accumulate near a toner supply port and, therefore, it is sometimes impossible to keep a good toner amount detection accuracy of image formation units. If a good toner amount detection accuracy cannot be kept, a deficiency in the amount of toner and an uneven distribution of toner in the image formation units occur, which in turn deteriorates the image quality.

Second Embodiment

Next, a second embodiment of the invention is described. The overall configuration of an image formation apparatus of this embodiment is almost the same as that of the image formation apparatus of the first embodiment. Thus, the same components are given the same reference numerals and are not described again. FIG. **15** is a perspective view showing toner amount detection member **16** according to this embodiment.

Toner amount detection member **16** of this embodiment has variations in intervals at which protrusions **27**, **28** are arranged. Specifically, unlike in the first embodiment where all protrusions **27**, **28** are arranged at equal intervals, protrusions **27**, **28** of this embodiment are arranged in such a way that their arrangement interval gradually increases. More specifically, arrangement interval L increases away from toner supply port **15**. As shown in FIG. **15**, the values of L1 close to toner supply port **15**, L2 farther from toner supply port **15** than L1, and L3 farther from toner supply port **15** than L2 are defined to gradually increase in the following way:

L1<L2<L3. The configuration of the apparatus of this embodiment is the same as that of the first embodiment except for this point.

The image formation apparatus having the above configuration operates as follows. Note that, since the overall operation of the apparatus is the same as that of the first embodiment, the operation of protrusions **27**, **28** is mainly described here.

As in the first embodiment, toner **13** is conveyed in the axial directions of toner amount detection member **16** by the rotation of toner amount detection member **16** and protrusions **27**, **28**. In this event, because the arrangement interval of protrusions **27**, **28** is small near toner supply port **15**, toner **13** can reach next protrusions **27**, **28** quickly. Thus, the amount of toner which can be conveyed is large.

By contrast, the arrangement interval of protrusions **27**, **28** is large at positions far from toner supply port **15**. Accordingly, portions with no protrusions **27**, **28** are each large, making it difficult to convey toner **13** in the axial directions. Thus, the amount of toner which can be conveyed becomes smaller away from supply port **15**.

The operations of the apparatus of this embodiment are the same as those of the first embodiment except for the above.

In the first embodiment, the toner distribution which is uneven immediately after the toner supply, as shown in FIG. **16**A, becomes even after the elapse of period Ta to a level toner as shown in FIG. **16**B. In this case, if toner is not supplied for a long period (e.g. in the case where toner **13** is not consumed so much because low-density printing is repeated), toner **13** gathers at both ends of image formation unit **1**K and exhibits an uneven distribution as shown in FIG. **16**C after the elapse of stir period Tb. The difference between the levels of toner **13** (toner distribution difference) inside image formation unit **1**K at this time is set at h1, which is a difference between the levels of toner upper surfaces in a central portion, in the longitudinal direction of image formation unit **1**K, and in each end portion thereof in the longitudinal direction.

On the other hand, in this embodiment where the arrangement interval of protrusions **27**, **28** is adjusted, the toner distribution, which is uneven immediately after the toner supply as shown in FIG. **17**A, becomes even after the elapse of period Ta' to level toner as shown in FIG. **17**B, and then becomes uneven after the elapse of stir period Tb as shown in FIG. **17**C. The toner distribution difference at this time is set at h2.

In both the first and second embodiments, the distribution of toner **13** becomes uneven after the elapse of period Tb to a degree not adversely affecting a print image. However, since the amount of toner which can be conveyed varies because of the variations in the interval of protrusions **27**, **28**, the toner distribution difference inside image formation unit **1**K in these embodiments results in h1>h2. Thus, the second embodiment enables the toner distribution to be kept closer to an even distribution when evenly distributed toner is further stirred. As a result, it is possible to keep a good toner amount detection accuracy while more effectively preventing a deterioration thereof, and also to keep a good image quality while more effectively preventing deterioration thereof due to a deficiency in the amount of toner and an uneven distribution of the toner.

It should be noted that the invention relates to an image formation unit which is applicable to various image formation apparatuses. For example, the image formation unit of the invention is applicable to image formation apparatuses used as copiers, LED printers, laser printers, facsimiles, MFPs, and the like.

In addition, although the arrangement interval L of protrusions **27**, **28** is increased gradually away from toner supply port **15** in the second embodiment, this arrangement interval

L may be set more exactly. Specifically, since toner **13** has fluidity, and even deteriorated toner has fluidity to some extent, arrangement interval L of protrusions **27**, **28** may be adjusted accordingly. More specifically, arrangement interval L of protrusions **27**, **28** may be adjusted so that the amount of toner **13** flowing toward the center, in the longitudinal direction, of toner amount detection member **16** attributable to the fluidity of a deteriorated toner balances with the amount of toner conveyed toward the two sides thereof in the longitudinal direction by toner amount detection member **16** of the second embodiment. The amount of toner **13** to flow toward the center of toner amount detection member **16** that is attributable to the fluidity of deteriorated toner varies depending on various conditions, such as the degree of deterioration of toner **13**. Accordingly, in a practical case, the values of the fluidity of toner according to these conditions are determined through experiments. Then, arrangement interval L of protrusions **27**, **28** is adjusted so as to balance with the fluidity of the toner. Thereby, the toner distribution difference h2 can be reduced to a value close to 0. Further, angles θ, α of protrusions **27**, **28** may be adjusted instead of, or together with, the adjustment of arrangement interval L of protrusions **27**, **28**.

The apparatus in each of the embodiments has a configuration where toner supply port **15** is provided to the central portion, in the longitudinal direction, of developer housing portion S and protrusions **27**, **28** of toner amount detection member **16** spread toner **13** in the central portion thereof in the longitudinal direction toward the two sides thereof. However, the apparatus may have another configuration. Specifically, toner supply port **15** may be disposed, not in the central portion in the longitudinal direction of developer housing portion S, but in a portion slightly shifted left or right from the central portion, or in a portion largely shifted left or right from the central portion. In this case, a set of protrusions **27** and a set of protrusions **28** are arranged left and right about a position immediately under toner supply port **15**. In the case where toner supply port **15** is provided at left or right ends of toner amount detection member **16**, only protrusions **27** or only protrusions **28** are provided. In either case, the same working effect as those of the above embodiments can be achieved.

Moreover, although the four image formation units are provided for color printing in the above embodiments, only one image formation unit is provided in the case of monochrome printing. The invention is also applicable to this case.

In addition, the invention is not limited to the above embodiments, but may be embodied by modifying the constituents thereof within a range not departing from the spirit of the invention in a practical phase. Further, various aspects of the invention can be provided by appropriately combining two or more of the constituents disclosed in the above embodiments.

For example, some of the constituents out of all the constituents in the above embodiments and modifications may be combined or deleted. Furthermore, constituents according to another embodiment may be used in combination as appropriate.

The invention includes other embodiments in addition to the above-described embodiments without departing from the spirit of the invention. The embodiments are to be considered in all respects as illustrative, and not restrictive. The scope of the invention is indicated by the appended claims rather than by the foregoing description. Hence, all configurations including the meaning and range within equivalent arrangements of the claims are intended to be embraced in the invention.

The invention claimed is:

1. An image formation unit comprising:
- a developer storage configured to store developer;
- an image carrier on which an electrostatic latent image is formed;
- a developer carrier facing the image carrier and configured to transfer developer to the electrostatic latent image;
- a developer housing portion located below the developer storage and configured to house the developer from the developer storage;
- a supply port configured to supply the developer in the developer storage into the developer housing portion;
- a developer amount detection member rotatably disposed in the developer housing portion at a position below the supply port; and
- protrusions disposed on the developer amount detection member,
- wherein, with respect to an axial direction of the developer amount detection member, an interval between each adjacent protrusions is greater at end portions of the developer amount detection member than at a center portion of the developer amount detection member.

2. The image formation unit according to claim **1**, wherein the protrusions work in conjunction with one another to spread the developer supplied through the supply port in a longitudinal direction of the developer amount detection member.

3. The image formation unit according to claim **1**, wherein the protrusions are arranged in parallel with one another on a flat plate which is provided to extend in a direction of a rotational axis of the developer amount detection member and to protrude in a radial direction.

4. The image formation unit according to claim **3**, wherein the flat plate of the developer amount detection member has:
- a leading surface in a direction of rotation of the developer amount detection member; and
- a trailing surface in the direction of rotation of the developer amount detection member, the trailing surface being opposed to the leading surface, and
- the protrusions are arranged on the trailing surface of the flat plate.

5. The image formation unit according to claim **4**, wherein each of the protrusions is disposed to be inclined in such a manner as to extend in a radial direction of the rotation axis of the developer amount detection member from the rotation axis and in a direction from an end portion of the flat plate toward the supply port.

6. The image formation unit according to claim **1**, wherein an interval between each adjacent protrusions increases away from the supply port.

7. The image formation unit according to claim **1**, wherein the developer amount detection member has a smooth surface on a leading surface relative to a direction of rotation of the development amount detection member, and
- the protrusions are provided on a surface opposed to the smooth surface.

8. The image formation unit according to claim **1**, wherein the developer amount detection member rotates to convey the developer in a direction where the developer amount detection member extends.

9. The image formation unit according to claim **8**, wherein the developer amount detection member conveys the developer in a direction away from the supply port.

10. An image formation apparatus comprising at least one image formation unit according to claim **1**.

11. An image formation unit comprising:
a developer storage configured to store developer;
an image carrier on which an electrostatic latent image is formed;
a developer carrier facing the image carrier and configured to transfer developer to the electrostatic latent image;
a developer housing portion located below the developer storage and configured to house the developer from the developer storage;
a supply port configured to supply the developer in the developer storage into the developer housing portion;
a developer amount detection member rotatably disposed in the developer housing portion at a position below the supply port; and
protrusions disposed on the developer amount detection member,
wherein the developer amount detection member is rotatable to convey the developer in a direction where the developer amount detection member extends,
wherein the protrusions are arranged in parallel with one another on a flat plate and extend from a radial end portion of the flat plate,
wherein the protrusions are inclined in such a manner as to radially extend toward the rotational axis of the developer amount detection member and extend from a center area toward an end of the developer amount detection member in the axial direction.

12. The image formation unit according to claim 11, wherein the developer amount detection member is configured to convey the developer in a direction away from the supply port.

13. The image formation unit according to claim 12, wherein the developer amount detection member has:
a conveyance portion configured to convey the developer; and
a developer reception portion configured to receive pressure from accumulated developer.

14. An image formation apparatus comprising at least one image formation unit according to claim 11.

15. The image formation unit according to claim 11, wherein the flat plate of the developer amount detection member affects a center of gravity of the developer amount detection member such that, after the flat plate passes a top point of the rotation of the developer amount detection member in the rotational direction, the developer amount detection member rotates due to its own weight.

16. The image formation unit according to claim 15, wherein the flat plate extends radically outward from a remaining portion of the developer amount detection member.

17. The image formation unit according to claim 11, wherein the protrusions are inclined at an angle α, wherein $0<\alpha<90°$.

18. An image formation unit comprising:
a developer storage configured to store developer;
an image carrier on which an electrostatic latent image is formed;
a developer carrier facing the image carrier and configured to transfer developer to the electrostatic latent image;
a developer housing portion located below the developer storage and configured to house the developer from the developer storage;
a supply port configured to supply the developer in the developer storage into the developer housing portion;
a rotation member rotatably disposed in the developer housing portion at a position below the supply port, wherein the rotation member is rotatable to convey the developer in a direction where the rotation member extends, wherein the rotation member is formed with a flat plate radially extending with respect to a rotational axis of the rotation member; and
protrusions arranged substantially parallel with one another and extending from a radial end portion of the flat plate,
wherein the protrusions are inclined in such a manner as to face a center portion of the rotation member in the axial direction of the rotation member, such that a first subset of the protrusions on a first portion of the flat plate are inclined in a first direction with respect to the flat plate and such that a second subset of the protrusions on a second portion of the flat plate are inclined in a second direction with respect to the flat plate, the first direction being different from the second direction.

19. The image formation unit according to claim 18, wherein the flat plate of the rotation member affects a center of gravity of the rotation member such that, after the flat plate passes a top point of the rotation of the rotation member in the rotational direction, the rotation member rotates due to its own weight.

20. The image formation unit according to claim 18, wherein the protrusions are inclined at an angle α, wherein $0<\alpha<90°$.

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